RESULTS AND DISCUSSION

IV. RESULTS AND DISCUSSION

This work included two experiments. First one was dealing with investigating the effect of some citrus rootstocks on Valencia orange cv. However, second one devoted to investigate the effect of the two grafting dates on olive transplant. Such effects were evaluated through the response of some vegetative growth measurements, nutritional status (leaf mineral composition), some chemical constituents and anatomical structure of union zone.

Therefore, obtained results from this study dealing with any of the abovementioned four aspects for each experiment are separately discussed during both seasons of study as follows:

I- Response of some vegetative growth measurements.

II- Response of some nutritional status (leaf mineral contents).

III- Response of some chemical constituents .

IV. Anatomical studies.

The first experiment: Effect of the different citrus rootstocks on:

I. Some vegetative growth measurements.

I.1- Percentage of success

With regard to the effect of investigated citrus rootstocks seedlings under study i.e., (Volkamer lemon, Sour orange and Balady lime) on the success percentage, data tabulated in **Table (1)** revealed clearly that, the greatest value of success percentage was resulted by the Valencia orange Cv. budded on Volkamer lemon rootstock seedlings followed statistically in a descending order by Valencia orange Cv. budded on both Sour orange and Balady lime rootstocks, respectively. In other words, data indicated obviously that, the Valencia orange Cv. budded on Volkamer lemon rootstock seedlings was statistically the superior however, the highest values of success percentage (96.89 % & 97.47 %) were induced in first and second seasons, respectively. Whereas, the reverse was true with the Valencia orange Cv. budded on Balady lime rootstock seedlings which exhibited statistically the least values of success percentage (79.46 % & 81.34 %) 1st and 2nd seasons of study, respectively.

On the other hand, Valencia orange Cv. budded on Sour orange rootstock seedlings ranked statistically the second as compared to either the superior (Volkamer lemon) or the inferior one (Balady lime) throughout both 2008 and 2009 seasons of study.

The obtained data regarding the effect of different investigated citrus rootstock seedlings on the success percentage are in general agreement with those reported by **Atawia (1992), Martinez *et al.* (1994), Gonzalez and Figueroa (1996), and Dubey *et al.* (2004).**

I.2- Scion length (cm)

Concerning the response of scion length (cm) of Valencia orange Cv. to the different studied citrus rootstock seedlings used in this work i.e., (Volkamer lemon, Sour orange and Balady lime), obtained data represented in the abovementioned **Table (1)** showed clearly that, the highest values of scion length was in closed relationship with Valencia orange Cv. budded on Vokamer lemon rootstock seedlings i.e., (27.80 % & 24.60cm) in the first and second seasons, respectively.

On the other hand, the opposite was detected with Valencia orange Cv. budded on Sour orange rootstock seedlings. Since, budded Valencia orange transplants on Sour orange exhibited statistically the least values of scion length (12.40 & 9.60 cm) during 2008 and 2009 seasons, respectively. In addition, Valencia orange Cv. budded on Balady lime rootstocks came in between the aforesaid two extents. Differences were significant as each type of citrus rootstocks was compared to the two other ones. Such trend was detected during both 2008 and 2009 seasons of study.

The obtained results concerning the effect of some citrus rootstocks on scion length go in line with those mentioned by **Hassan (1984), Continella *et al.* (1988), Monteverde (1989), Monteverde *et al.* (1990), Abd El-Rahman (1994), Salem *et al.* (1994), Gonzalez and Figueroa (1996) and Dubey *et al.* (2004).**

I.3- Scion diameter (cm)

As for the effect of the different types of citrus rootstocks i.e., (Volkamer lemon, Sour orange and Balady lime) on scion diameter (cm) of Valencia orange Cv. it is quite evident from tabulated data in **Table (1)** that, the same trend previously found with scion length parameter was detected in this regard. In other words, Valencia orange Cv. budded on Volkamer lemon rootstock seedlings was the superior followed statistically in a descending order by Valencia orange Cv. budded on both Balady lime and Sour orange rootstocks, respectively.

On the other hand, it could be noticed that, differences in scion diameter of Valencia orange Cv. budded on either Sour orange or Balady lime rootstock seedlings was not so pronounced especially in the second season. Where differences didn't reach level of significance.

Table (1): Some vegetative growth measurements (success %, scion length and scion diameter) of Valencia orange transplants in response to citrus rootstocks used during both 2008 and 2009 seasons.

Characters / Type of citrus rootstock	Success %	Scion length	Scion diameter
The first season (2008)			
Volkamer lemon (*C. volkameriana*)	96.89A	27.80A	0.260A
Sour orange (*C. aurantium*)	92.77B	12.40C	0.100C
Balady lime (*C. aurantifolia*)	79.46C	21.00B	0.180B
The second season (2009)			
Volkamer lemon (*C. volkameriana*)	97.47A	24.60A	0.280A
Sour orange (*C. aurantium*)	89.64B	9.60C	0.120B
Balady lime (*C. aurantifolia*)	81.34C	19.20B	0.160B

Means followed by the same letter/s within each column are not significantly different from each other at 0.05 level.

I.5- Leaf area (cm^2).

Table (2): Some vegetative growth measurements (No. of leaves, leaf area and root length) of Valencia orange transplants in response to citrus rootstocks used during both 2008 and 2009 seasons.

Characters / Type of citrus rootstock	Number of leaves/plant	Leaf area (cm.)	Root length (cm.)
The first season (2008)			
Volkamer lemon (*C. volkameriana*)	26.80A	24.04A	26.20A
Sour orange (*C. aurantium*)	10.20C	14.90C	11.40C
Balady lime (*C. aurantifolia*)	14.80B	18.84B	18.80B
The second season (2009)			
Volkamer lemon (*C. volkameriana*)	25.00A	24.17A	25.60A
Sour orange (*C. aurantium*)	9.40C	15.24C	9.00C
Balady lime (*C. aurantifolia*)	13.00B	20.04B	18.40B

Means followed by the same letter/s within each column are not significantly different from each other at 0.05 level.

those budded on Balady lime rootstocks. On the other hand, the opposite was found with Valencia orange Cv. budded on Sour orange which statistically induced the shortest root. Such trend was detected during both 2008 and 2009 seasons of study.

In general, the present results are coincident in most cases with those reported by **Martinez *et al.* (1994), Abou-Rawash *et al.* (1995) and Dawood (1996).**

I.7- Fresh and dry weight of root and shoot systems:

The fresh and dry weights of both root and shoot of budded Valencia orange transplants as influenced by citrus rootstocks under study i.e., Volkamer lemon, Sour orange and Balady lime during two 2008 and 2009 seasons were the investigated four growth parameters in this respect. Obtained data during both experimental seasons of study are tabulated in **Table (3)**.

As for the response of fresh and dry weights of both root and shoot systems of Valencia orange transplants to citrus rootstocks, data obtained during both 2008 and 2009 experimental seasons are presented in **Table (3)**. It could be generally detected that four growth parameters followed to great extent the same trend with few exceptions. Hence, the heaviest fresh and dry weights of both root and shoot systems were significantly coupled with Valencia orange transplants budded on Volkamer lemon rootstock during two seasons.

On the other hand, budded Valencia transplants on two other citrus rootstocks could be descendingly arranged whereas those on Balady lime ranked statistically 2nd while there on Sour orange came latest particularly as shoot fresh and root dry weights were concerned during both 2008 and 2009 seasons.

Table (3): Fresh and dry weights of both shoot and root zone of Valencia orange transplants in response to citrus rootstocks used during both 2008 and 2009 seasons.

Characters / Type of citrus rootstock	Fresh weight of root (gm)	Fresh weight of graft (gm.)	Dry weight of root (gm)	Dry weight of graft (gm.)
The first season (2008)				
Volkamer lemon (*C. volkameriana*)	41.09A	20.33A	17.09A	7.468A
Sour orange (*C. aurantium*)	20.89B	14.28C	8.47C	4.758B
Balady lime (*C. aurantifolia*)	11.99C	17.10B	10.01B	5.211B
The second season (2009)				
Volkamer lemon (*C. volkameriana*)	41.28A	19.67A	15.92A	10.28A
Sour orange (*C. aurantium*)	21.54B	13.70C	8.10C	5.018B
Balady lime (*C. aurantifolia*)	11.77C	17.37B	9.65B	5.158B

Means followed by the same letter/s within each column are not significantly different from each other at 0.05 level.

In addition, difference in shoot dry weight of budded Valencia transplants was too slight to reach level of significance when there on either Sour orange or Balady lime were compared each other during two seasons. Meanwhile, trend took the other way around with root fresh weight of Valencia orange transplant when those on Sour orange and Balady lime were compared each other, where those on Sour orange exceeded statistically the analogous ones on Balady lime during both seasons.

The obtained results concerning the response of both fresh and dry weights for both shoot & root organs to the various investigated citrus rootstocks were supported by the findings of several investigators, **Salem *et al.* (1990), El-Ezaby (1994), Martinez *et al.* (1994), Abou-Rawash *et al.* (1995) and Dawood (1996).**

IV.II- Leaf mineral contents (nutritional status).

In this regard the leaf mineral contents of budded Valencia orange transplants as affected by citrus rootstocks i.e., (Volkamer lemon, Sour orange and Balady lime) were investigated. The leaf nitrogen, phosphorus, potassium, calcium, magnesium, iron, zinc and manganese contents estimated each as a ratio on the dry weight base as a percentage for the five macro-elements i.e., (N, P, K, Ca and Mg) and part per million (ppm) for the three micro-nutrients (Fe, Zn and Mn) were concerned. The obtained results during both 2008 and 2009 seasons were tabulated in **Tables (4 and 5)**.

II.1- Leaf nitrogen content:

Concerning the leaf nitrogen content of Valencia orange cultivar in response to the effect of investigated rootstock used

II.4- Leaf calcium content:

With respect to the effect of different investigated of citrus rootstocks (Volkamer lemon, Sour orange and Balady lime) on the calcium content of Valencia orange leaves, data tabulated in **Table (4)** indicated clearly that, the richest leaves in their calcium content was in closed relationship with those Valencia orange transplants budded on Volkamer lemon rootstocks. However, differences were significant with comparing with the corresponding ones on Balady lime rootstock only during both seasons. Meanwhile, variations were top slight be taken into consideration from statistical point of view as Valencia orange transplants budded on Volkamer lemon & Sour orange rootstocks compared each other during both seasons.

The present results are in a general agreement with those mentioned by some investigators, **Saad-Allah *et al.* (1985), Kaplankiran and Ozsan (1986) and Faiz *et al.* (1993),**

II.5- Leaf magnesium content:

With regard the influence of the various used type of citrus rootstocks on the magnesium content of Valencia orange leaves, it is quite evident from tabulated data in **Table (4)** that, the richest leaves and the highest value of leaf Mg content was significantly resulted by Valencia orange transplants budded on Volkamer lemon rootstock. This trend was true during two seasons of study. Moreover, Valencia orange transplant budded on Sour orange rootstocks induced an increase in leaf Mg content than the other ones budded on Balady lime rootstock. Difference between two citrus rootstocks (Sour orange and Balady lime) was significant as compared in the first season only. Meanwhile, in the second 2009 season the response was completely absent from the statistical standpoint.

Table (4): Leaf macro elements (N, P, K, Ca and Mg) of Valencia orange transplants in response to citrus rootstocks used during both 2008 and 2009 seasons.

Characters / Type of citrus rootstock	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
The first season (2008)					
Volkamer lemon (*C. volkameriana*)	2.56A	0.264A	1.78A	3.67A	1.60A
Sour orange (*C. aurantium*)	2.49AB	0.228B	1.51B	3.50A	1.44B
Balady lime (*C. aurantifolia*)	2.38B	0.215B	1.22C	3.13B	1.21C
The second season (2009)					
Volkamer lemon (*C. volkameriana*)	2.71A	0.287A	1.83A	3.74A	1.48A
Sour orange (*C. aurantium*)	2.53B	0.216B	1.64B	3.61A	1.26B
Balady lime (*C. aurantifolia*)	2.29C	0.223B	1.20C	3.17B	1.19B

Means followed by the same letter/s within each column are not significantly different from each other at 0.05 level.

In general, the present results are coincident in most cases with those reported by **Procopiou and Wallace (1979), Kaplankiran and Ozsan (1986), Fallahi and Rodney (1992) and Faiz *et al.* (1993).**

II.6- Leaf iron content:

Concerning the effect of the different studied citrus rootstock types used in this work on the leaf iron content of Valencia orange transplant data represented in **Table (5)** displayed obviously that, Valencia orange transplants budded on Volkamer lemon rootstocks had leaves contained the greatest leaf Fe content followed in a descending order by those budded on Sour orange and Balady lime rootstocks, respectively. Moreover, the superiority of the Volkamer lemon rootstock over two other investigated ones was clearly observed throughout the first and second seasons of study. The reverse was true with Valencia orange transplants budded on Balady lime rootstock which induced the poorest leaves iron content during both 2008 and 2009 seasons. Furthermore, the differences in leaf Fe contents of Valencia orange transplants due to citrus rootstocks used were significant as 3 investigated ones i.e., Volkamer lemon, Sour orange and Balady lime rootstocks compared each other. Such trend was detected during both seasons of study.

Data obtained on the influence of some investigated citrus rootstocks on the iron content were supported by the findings of **Saad-Allah *et al.* (1985), Kaplankiran *et al.* (1986) and Faiz *et al.* (1993).**

II.7- Leaf zinc content:

With respect to the leaf zinc content of Valencia orange transplants in response to the effect of different citrus rootstocks used i.e., Volkamer lemon, Sour orange and Balady lime, **Table (5)** shows clearly that, leaves of Valencia orange transplants budded on Volkamer lemon rootstock were significantly the richest. Meanwhile, those Sour orange rootstocks statistically ranked second in this concern. However, Valencia orange transplants budded on Balady lime rootstocks came last as their leaves zinc content was concerned. Such trend was detected during 2008 and 2009 seasons.

The present results are in a general agreement with those mentioned by some investigators, **Hassan (1984), Mokhtar (1984), Saad-Allah *et al.* (1985), Kaplankiran and Ozsan (1986) and El-Shazly (1996).**

IV.II.8- Leaf manganese content:

Regarding the leaf manganese content of Valencia orange Cv. in response to the three investigated types of citrus rootstocks i.e., (Volkamer lemon, Sour orange and Balady lime), data presented in **Table (5)** displayed obviously that, the richest leaves in their Mn content was significantly coupled with those of Valencia orange transplants budded on Volkamer lemon rootstocks followed in a descending order by those budded on Sour orange and Balady lime rootstocks. Hence, those of Balady lime ranked the last and were statistically the inferior as their leaves had the least value Mn level. Moreover, it could be observed from obtained data that the differences in leaf Mn content between the three types of investigated citrus rootstocks (Volkamer lemon, Sour orange and Balady lime) were significant as they were compared each other. Such trend was true during both experimental seasons.

The obtained results concerning the effect of some citrus rootstocks on manganese content go in line with those mentioned by **Hassan (1984), Mokhtar (1984), Kaplankiran and Ozsan (1986), Faiz *et al.* (1993), Kaplankiran and Tuzcu (1994), Abou-Rawash *et al.* (1995), Azab (1995).**

the contrary, the poorest leaves in their chlorophyll b content and the least value were significantly in closed relationship to Valencia orange transplants budded on Balady lime rootstocks. Such trend was true during both 2008 and 2009 seasons.

Regarding the effect due to the different citrus rootstocks used in this investigation i.e., (Volkamer lemon, Sour orange and Balady lime) on the leaf total chlorophyll (a + b) content of Valencia orange transplants data represented in **Table (6)** revealed clearly that, the response typically followed the same trend previously detected with both leaf chlorophyll a and b content. Since, the richest leaves and the highest values of leaf total chlorophyll (a + b) was always in concomitant to the Valencia orange transplants budded on Volkamer lemon rootstock. Whereas, the reverse was true with the Valencia orange transplants budded on Balady lime rootstocks. In other words, the leaf total chlorophyll (a + b) content as influenced by the three investigated citrus rootstocks under study could be safely arranged according to the citrus rootstock used into the following descending order 1. Volkamer lemon rootstocks; 2. Sour orange rootstocks; 3. Balady lime rootstocks, respectively. Such trend was true throughout the first and second seasons of study.

III.2-Carotenoids:

Referring the leaf carotenoids content of Valencia orange leaves as influenced by the citrus rootstocks used i.e., Volkamer lemon, Sour orange and Balady lime, data represented in **Table (6)** displayed obviously that, Valencia orange transplants budded on Volkamer lemon, rootstock induced leaves with the highest carotenoids content that surpassed statistically the analogous ones of the other (Valencia orange transplants budded

Table (6) :Leaf photosynthetic pigments (chlorophyll A, B and carotenoids) content of Valencia orange transplants in response to citrus rootstocks used during both 2008 and 2009 seasons.

Phytosynthetic pigments / Type of citrus rootstock	Chlorophyll (a)	Chlorophyll (b)	Total chlorophyll	Carotenoids
The first season (2008)				
Volkamer lemon (*C. volkameriana*)	7.03A	6.91A	13.94A	3.99A
Sour orange (*C. aurantium*)	5.66B	5.27B	10.92B	3.64A
Balady lime (*C. aurantifolia*)	4.85C	4.27C	9.11C	2.93B
The second season (2009)				
Volkamer lemon (*C. volkameriana*)	6.86A	6.74A	13.60A	4.21A
Sour orange (*C. aurantium*)	5.14B	4.93B	10.07B	3.61B
Balady lime (*C. aurantifolia*)	4.24C	4.18C	8.42C	2.40C

Means followed by the same letter/s within each column are not significantly different from each other at 0.05 level.

on both Sour orange and Balady lime citrus rootstocks). On the contrary, Valencia orange transplants budded on Balady lime rootstock seedlings exhibited the least value and the poorest leaves in their carotenoids content. In addition, Valencia orange transplants budded on Sour orange rootstocks resulted in leaves had on intermediate carotenoids content as compared to two other combinations of Volkmer lemon and Sour orange rootstocks. Such trend was detected during both 2008 and 2009 experimental seasons.

IV- Some chemical constituents:

IV.1- Total carbohydrates:

Concerning the influence of various investigated citrus rootstocks in i.e., Volkamer lemon, Sour orange and Balady lime on shoot total carbohydrates content of Valencia orange Cv. data represented in Table (7) displayed clearly that, the highest value of total carbohydrates content was significantly exhibited by Valencia orange transplants budded on Volkamer lemon rootstocks. Meanwhile the least value carbohydrates content was always in concomitant with Valencia orange transplants budded on Balady lime rootstock. On the other hand, Valencia orange transplants budded on Sour orange rootstock was intermediate the abovementioned two extremes. The differences in carbohydrates content between the three types of citrus rootstocks were significant as they compared each other. Such trend was detected during both 2008 and 2009 seasons.

IV.2- Starch:

Regarding the response of starch content of Valencia orange to the citrus rootstocks used i.e., (Volkamer lemon, Sour orange and Balady lime), it is obvious from results tabulated in

Table (7) that, the greatest and the highest value of starch content was significantly in relationship with Valencia orange budded on Volkamer lemon. However, the opposite was found with Valencia orange budded on Balady lime rootstock which induced the least value of starch. Moreover, shoot starch content of Valencia orange transplants budded on Sour orange rootstock was moderately influenced as compared to two other combinations both seasons of study.

IV.3- Total indoles:

Considering the effect of the different investigated citrus rootstocks i.e., Volkamer lemon, Sour orange and Balady lime on the total indoles content of Valencia orange Cv. data represented in the same **Table (7)** revealed obviously that, the response typically followed the same trend previously detected with both total carbohydrates and starch contents. Whereas, the highest value of total indoles was always in concomitant to the Valencia orange transplants budded on Volkamer lemon rootstock. On the other hand, the reverse was detected with the Valencia orange Cv. budded on Balady lime rootstock which exhibited the least value of total indoles. In addition, Valencia orange Cv. budded on Sour orange rootstock had considerably an intermediate level total indoles as compared to the analogous values of two other combinations. Such trend was true during both 2008 and 2009 experimental seasons.

IV.4- Total phenols:

With respect to the effect of the different investigated citrus rootstock i.e., Volkamer lemon, Sour orange and Balady lime on the total phenols content of Valencia orange leaves, data tabulated in **Table (7)** revealed obviously that, the highest values of total phenols of Valencia orange leaves content was

Table (7): Some chemical components (total carbohydrates, starch, total indoles and phenols) of Valencia orange transplants in response to citrus rootstocks used during 2008 and 2009 seasons.

Characters / Type of citrus rootstock	Total carobhydrates	Starch	Tota indoles	Total phenols
The first season (2008)				
Volkamer lemon (*C. volkameriana*)	23.98A	17.22A	11.43A	136.2C
Sour orange (*C. aurantium*)	19.36B	14.12B	6.39B	150.8B
Balady lime (*C. aurantifolia*)	18.63C	12.40C	6.15C	188.4A
The second season (2009)				
Volkamer lemon (*C. volkameriana*)	24.61A	18.41A	11.67A	141.2C
Sour orange (*C. aurantium*)	21.33B	14.91B	6.76B	167.5B
Balady lime (*C. aurantifolia*)	17.46C	12.91C	5.97C	205.8A

Means followed by the same letter/s within each column are not significantly different from each other at 0.05 level.

always in concomitant with those budded on Balady lime rootstock. However, the least value of total phenols content was significantly exhibited by those Valencia orange Cv. budded on Volkamer lemon rootstocks. In addition budded on Sour orange rootstock came in between the abovementioned two extremes with variable tendency of effectiveness. Moreover, differences were differences three combinations of budded Valencia orange transplants compared each other. Such trend was true during both 2008 and 2009 experimental seasons of study. Hence, the trend of total phenol content in response to three citrus rootstocks took the other way around as compared to those detected with total carbohydrates, starch and indoles.

V- Anatomical study of citrus union zone.

V.1- Citrus:

Data in **Table (8)** and **Fig.(1)** indicated that, anatomical measurements (in microns) of cross section in union zone for Valencia orange scion on Volkamer lemon rootstock i.e., diameter of whole section, rootstock thickness, scion thickness, cortex thickness in rootstock, scion cortex thickness, cambium thickness in rootstock and xylem tissue thickness in rootstock were increased with increase the transplant age. On the other hand, vacuoles and necrotic tissues decreased with increase the transplant age.

Table (9) and **Fig.(2)** show that, anatomical measurements (in microns) of cross section in union zone for Valencia orange scion on Sour orange rootstock i.e., diameter of whole section, rootstock thickness, scion thickness, cortex thickness in rootstock, scion cortex thickness, cambium thickness in rootstock and xylem tissue thickness in rootstock were increased with increase the transplant age. On the other hand, vacuoles and necrotic tissues decreased with increase the transplant age.

Concerning to budded Valencia orange scion on Sour lemon rootstock, **Table (10)** and **Fig. (3)** cleared that, diameter of whole section, rootstock thickness, scion thickness, cortex thickness in rootstock, scion cortex thickness, cambium thickness in rootstock and xylem tissue thickness in rootstock were increased with increase the transplant age. On the other hand, vacuoles and necrotic tissues decreased with increase the transplant age.

Generally, it could be safely concluded from comparison between three rootstocks, data show that, the best results were obtained from budded Valencia orange scion on Volkamer lemon rootstock. Hence, all anatomical measurements especially the directly correlated ones with enhancing the process of compatibility to take place successfully were obviously higher with the Volkamer lemon x Valencia orange rather than two other ones (Valencia orange x Sour orange or Balady lime).

These results are in line with those obtained by **Hartmann and Kester (1978) and Shklarman *et al.*, (1994)** who declared that compatible and incompatible combinations of citrus species cannot affect satisfactory union which takes place after a year and it can be detected at an early stage. Moreover, **Fortanzza and Rugini (1983)** stated that, under compatible conditions the success of graft depends, from histological point of view, on vascular differentiation at the bud union zone. **Bakry *et al.*, (2006)** reported that, Microscopic examination of union zone between Sour orange interstock and Volkamer lemon rootstock showed also wider parenchymatous vacuoles

Table (8): Some anatomical measurements of cross section in union zone for Valencia orange scion on Volkamer lemon rootstock.

Transplant age / Measurements (microns)	15 days	30 days	60 days	120 days	240 days
Diameter of whole section	2984.08	3173.54	3417.45	5139.00	7524.00
Rootstock thickness	1613.77	1767.46	1818.69	2502.00	4815.00
Scion thickness	1216.62	1559.77	1598.76	2637.00	2709.00
Cortex thickness in rootstock	70.38	116.28	120.60	129.60	191.80
Scion cortex thickness	141.66	141.66	148.74	155.83	156.20
Cambium thickness in rootstock	27.00	40.50	48.60	51.30	84.60
Xylem tissue thickness in rootstock	307.66	317.43	390.68	562.50	1287.90
Secondary cortex thickness	125.82	217.08	253.96	255.60	270.45
Union zone thickness	122.40	140.76	153.00	161.40	239.70
No. of vacuoles	1	1	-	-	-
Vacuoles thickness	29.70	8.10	-	-	-
Thickness of necrotic layer	30.60	14.40	-	-	-

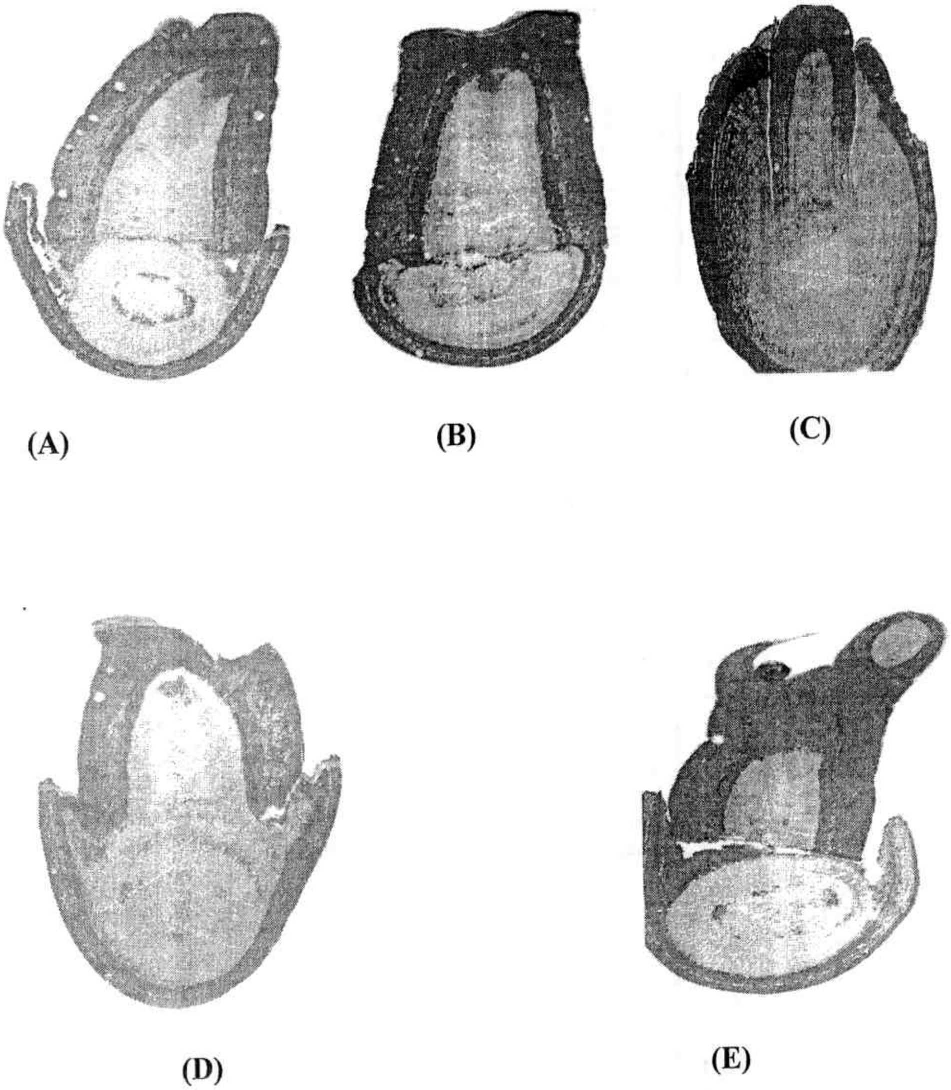


Fig.(1): Cross section in union zone for Valencia orange scion on Volkamer lemon rootstock (X= 50).

A- at 15 days age

B- at 30 days age.

C- at 60 days age.

D- at 120 days age.

E- at 240 days age.

S = Scion, R.S. = Rootstock, Co = Cortex, Ca= Cambium X. = Xylem, U.Z. = Union zone, V. = vacuoles, N. = Necrotic layer.

Table (9): Some anatomical measurements of cross section in union zone for Valencia orange scion on Sour orange rootstock.

Transplant age / Measurements (microns)	15 days	30 days	60 days	120 days	240 days
Diameter of whole section	2678.85	2780.92	3227.53	3427.79	4220.10
Rootstock thickness	1665.00	1793.07	1972.38	1998.00	2492.10
Scion thickness	1013.85	987.85	1255.15	1429.79	1216.62
Cortex thickness in rootstock	129.60	137.63	138.00	153.00	175.95
Scion cortex thickness	208.64	222.55	236.45	292.09	306.00
Cambium thickness in rootstock	25.38	27.00	45.90	50.40	102.60
Xylem tissue thickness in rootstock	280.80	256.38	316. 52	410.21	948.60
Secondary cortex thickness	222.15	253.80	301.95	320.43	321.30
Union zone thickness	112.50	162.18	168.60	189.72	198.90
No. of vacuoles	1	1	-	-	-
Vacuoles thickness	38.70	6.66	-	-	-
Thickness of necrotic layer	-	30.60	-	-	-

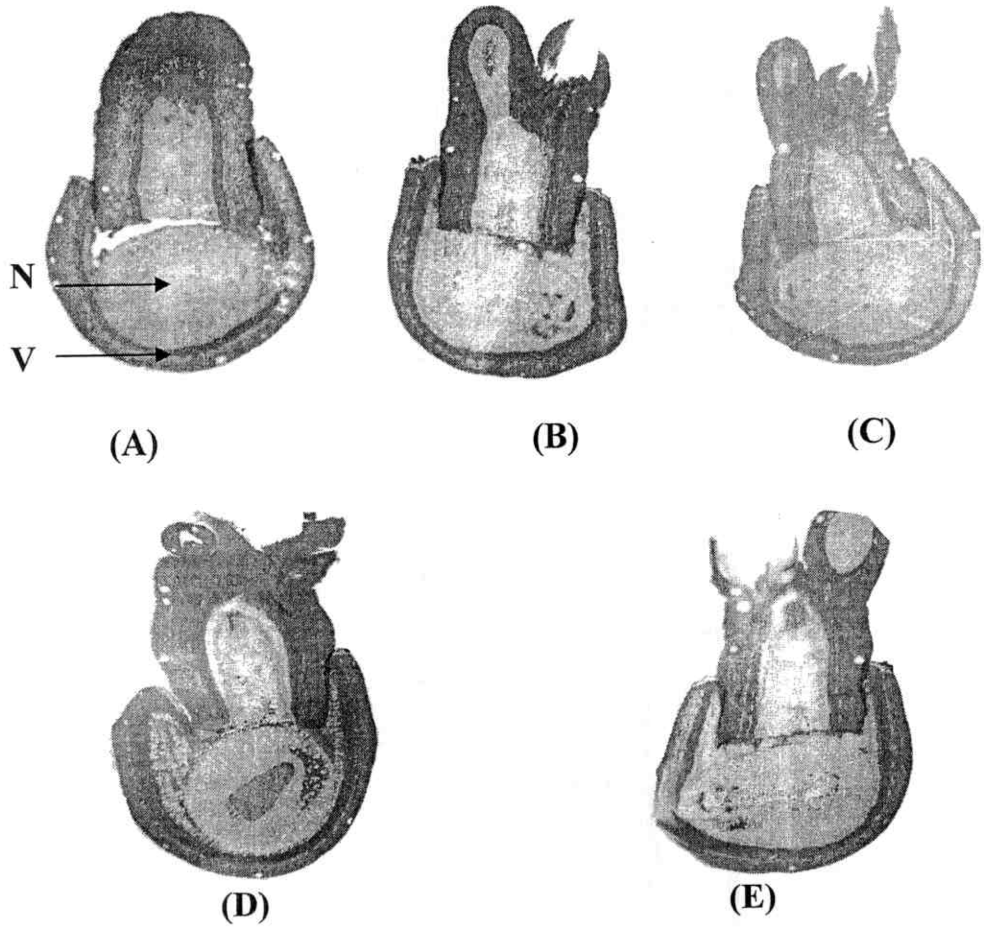


Fig.(2): Cross section in union zone for Valencia orange scion on sour orange rootstock (X= 50).

A- at 15 days age. B- at 30 days age.

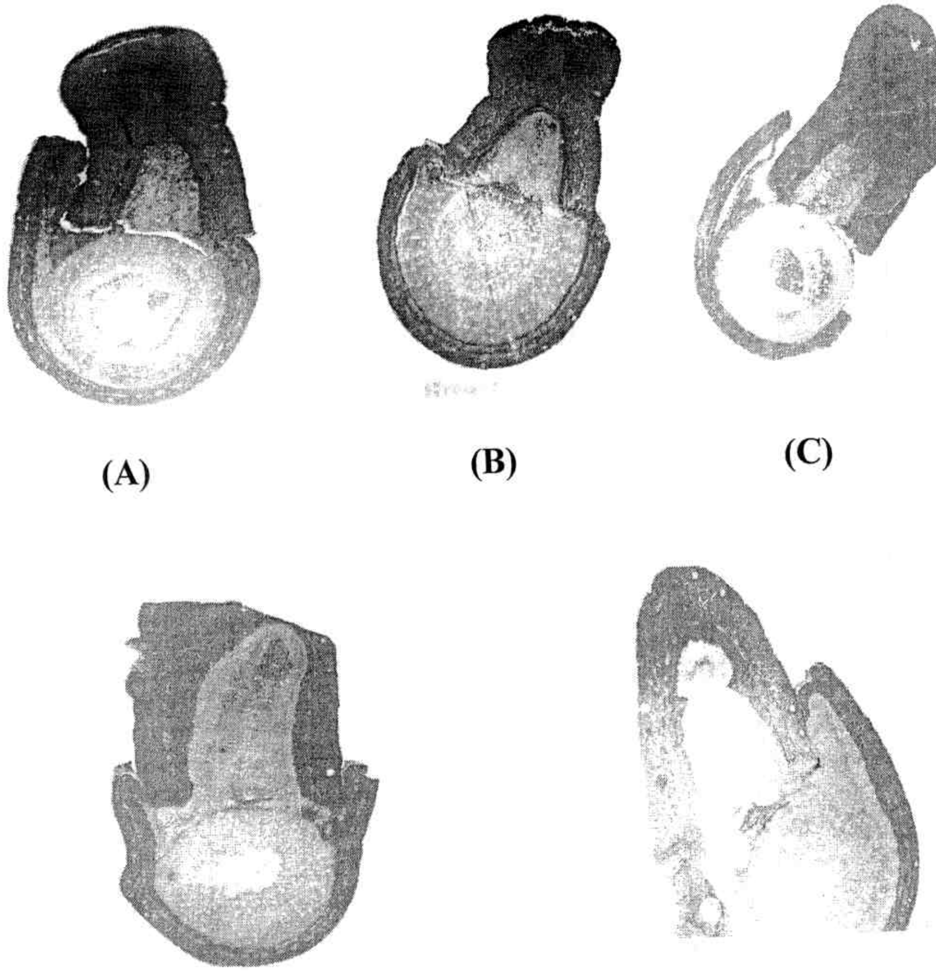
C- at 60 days age. **D**- at 120 days age

E- at 240 days age.

S = Scion, R.S. = Rootstock, Co = Cortex, Ca= Cambium X. = Xylem, U.Z. = Union zone, V. = vacuoles, N. = Necrotic layer.

Table (10): Some anatomical measurements of cross section in union zone for Valencia orange scion on Balady lime rootstock.

Transplant age / Measurements (microns)	15 days	30 days	60 days	120 days	240 days
Diameter of whole section	2602.76	2835.20	2975.33	3188.01	3401.52
Rootstock thickness	1536.92	1639.38	1716.23	1831.50	2023.62
Scion thickness	1065.84	1143.83	1195.82	1377.90	1481.78
Cortex thickness in rootstock	97.92	100.92	104.04	137.70	137.70
Scion cortex thickness	167.84	178.33	188.82	188.82	209.80
Cambium thickness in rootstock	24.30	45.90	51.30	52.65	54.00
Xylem tissue thickness in rootstock	316.52	415.09	456.61	463.93	512.77
Secondary cortex thickness	168.48	174.84	181.32	228.42	231.78
Union zone thickness	91.80	183.60	195.84	198.90	260.10
No. of vacuoles	1	1	-	-	-
Vacuoles thickness	20.70	18.45	-	-	-
Thickness of necrotic layer	38.25	30.60	-	-	-



(A) (B) (C)

(D) (E)

Fig.(3): Cross section in union zone for Valencia orange scion on Balady lime rootstock (X= 50).

A- at 15 days age. B- at 30 days age.

C- at 60 days age. D- at 120 days age.

E- at 240 days age.

S = Scion, R.S. = Rootstock, Co = Cortex, Ca= Cambium X. = Xylem, U.Z. = Union zone, V. = vacuoles, N. = Necrotic layer.

and necrotic tissues, besides narrower area of different union zone tissues, particularly secondary cortex were presented which gave a logic explanation for the depressive influence of Sour orange interstock on most growth parameters. However, the union process took place successfully.

The Second experiment: Effect of grafting dates on Kalamata olive Cv.:

IV.I- Some vegetative growth measurements:

In this respect the percentage of grafting success, scion length, scion diameter, number of leaves per plant, leaf area, root length, fresh and dry weights for both root and shoot systems were the ten growth measurements of the Kalamata olive Cv. pertaining their response to grafting dates i.e., (February & November) on Shemlali olive rootstock.

I.1- Percentage of success:

Referring the effect of the grafting data on the percentage of success, it is quite evident as shown from data tabulated in **Table (11)** that, Kalamata olive grafted on Shemlali olive rootstock in the first date (February) exhibited statistically the highest percentage of grafting success as compared to those grafted in the second date i.e., (November). Such trend was true during both 2008 and 2009 experimental seasons.

These results are general agreement with findings of **Sotomayor, *et al.*, (1994) and Santos and Calado (1996).**

I.2- Scion length:

With respect to the effect of the grafting date on the scion length, data obtained during both seasons of study displayed obviously as shown **Table (11)** that, the response followed typically the same trend previously detected with success. Whereas, shoot length of Kalamata olive Cv. grafted on Shemlali olive rootstock seedlings in the 1st date (February) was statistically the superior (33.32 & 33.34 cm) however those grafted in the second date (November)were statistically shorter (19.84 and 20.40 cm) during both 2008 and 2009 seasons, respectively.

I.3- Scion diameter:

As for the effect of the grafting date on the scion diameter of Kalamata olive Cv. grafted on Shemlali olive rootstock seedlings, results represented in **Table (11)** revealed obviously the superiority of the first date of grafting i.e., (February) which surpassed statistically the second date of grafting (November). Such trend was true and differences were significant during both seasons of study.

I.4- Number of leaves:

Regarding the effect of grafting dates (February or November) on the number of leaves per plant of Kalamata olive Cv. grafted on Shemlali olive rootstocks, it is so clear to be noticed that the response of number of leaves per plant followed typically an obvious firm trend. Hence, the higher values of this parameter (48.28 and 46.20) was always in closed relationship to Kalamata olive Cv. grafted on Shemlali olive rootstock on (February).

1.5- Leaf area (cm^2):

With respect to the leaf area of Kalamata olive Cv. grafted on Shemlali olive seedling in response to investigated grafting dates i.e., (February and November), data tabulated in **Table (12)** showed clearly that the leaf area parameter followed

Table (11): Some vegetative growth measurements (success %, scion length and scion diameter) of Kalamata olive cultivar as affected by grafting dates during both 2008 and 2009 seasons.

Characters / Dates	Success %	Shoot length (cm)	Shoot diameter (cm)
The first season (2008)			
February	88.34A	33.32A	0.528A
November	80.63B	19.84B	0.384B
The second season (2009)			
February	88.68A	33.44A	0.476A
November	80.77B	20.40B	0.388B

Means followed by the same letter/s within each column are not significantly different from each other at 0.05 level.

Table (12): Some vegetative growth measurements (No. of leaves, leaf area and root length) of Kalamata olive cultivar as affected by grafting dates during both 2008 and 2009 seasons.

Characters / Dates	Number of leaves/plant	Leaf area (cm^2)	Root length (cm.)
The first season (2008)			
February	48.28A	5.52A	14.00A
November	26.84B	4.12B	10.13B
The second season (2009)			
February	46.20A	5.85A	14.00A
November	27.44B	4.35B	10.31B

Means followed by the same letter/s within each column are not significantly different from each other at 0.05 level.

typically the same trend previously detected with number of leaves during both seasons of study. However, the greatest leaf area of Kalamata olive was in closed relationship with those grafted earlier in the date February. Meanwhile the smallest leaves of Kalamata olive plants was significantly in concomitant to those olive plants grafted in date November. Such trend was true during both 2008 and 2009 seasons.

I.6- Root length (cm):

With respect to the effect of grafting dates (February or November), on the root length of Kalamata olive Cv. grafted on Shemlali olive rootstock, it is quite evident from tabulated data in **Table (12)** that, the response of root length followed typically the same trend previously discussed with two formed parameters (number of leaves and leaf area). However, longer root was always in closed relationship to Kalamata olive Cv. grafted on Shemlali olive in February. On the contrary, the shortest root significantly resulted by Kalamata olive Cv. grafted in the second grafting date (November). Such trend was detected during both 2008 and 2009 seasons of study.

1.7- Fresh and dry weights of both root and shoot systems:

Fresh and dry weights of both root and shoot systems of Kalamata olive Cv. grafted on Shemlali olive rootstocks as influenced by the two investigated grafting dates (February & November), data obtained during both 2008 and 2009 experimental seasons are tabulated in **Table (13)**.

With respect to the fresh weights of both root and shoot systems of Kalamata olive Cv. grafted on Shemlali olive rootstocks in response to grafting dates (February & November), data represented in **Table (13)** showed clearly that, fresh weights measurements of both root and graft followed typically the same trend during the two seasons of study. Hence, highest value of both fresh weight parameters were statistically in concomitant to Kalamata olive Cv. grafted in February. However, the opposite was found with those grafted in the second grafting date (November).

Regarding the effect of the grafting dates i.e., (February & November) on root dry weight of Kalamata olive Cv. grafted on Shemlali olive rootstocks, data obtained during both 2008 and 2009 seasons as shown from **Table (13)** pointed out the negligible variation, whereas differences were so little to reach level of significance.

As for the effect of grafting dates (February & November) on shoot dry weight of Kalamata olive Cv. grafted on Shemlali olive rootstocks, data tabulated in **Table (13)** declared that, the Kalamata olive Cv. grafted on Shemlali olive rootstock in the second grafting date (November) induced statistically the heaviest scion dry weight. On the contrary, Kalamata olive Cv. grafted on Shemlali olive rootstocks in the first grafting date i.e., (February) resulted in lighter shoot dry weight. In addition, such trend was true during both 2008 and 2009 experimental seasons.

The obtained results were supported by the findings of **Aldarwish (2002).**

Table (13): Fresh and dry weights of both shoot and root of Kalamata olive cultivar as affected by grafting dates during both 2008 and 2009 seasons.

Characters / Dates	Fresh weight of root (gm)	Fresh weight of shoot (gm.)	Dry weight of root (gm)	Dry weight of shoot (gm.)
The first season (2008)				
February	14.09A	14.58A	6.04A	6.54B
November	10.04B	13.56B	5.62A	7.34A
The second season (2009)				
February	15.22A	14.40A	6.10A	6.16B
November	9.56B	13.59B	5.87A	7.58A

Means followed by the same letter/s within each column are not significantly different from each other at 0.05 level.

IV.II- Leaf mineral composition:

II.1- Leaf nitrogen content:

Considering the leaf nitrogen content of Kalamata olive Cv. grafted on Shemlali olive rootstocks in response to grafting dates, Table (14) displays clearly that, variations were too slight to taken into consideration from the statistical point of view during booth 2008 and 2009.

II.2- Leaf phosphorus content:

With regard to the leaf phosphorus content, **Table (14)** shows obviously that leaf phosphorus content of Kalamata olive Cv. grafted on Shemlali olive rootstocks responded to the grafting data. Since, Kalamata olive Cv. grafted on Shemlali olive rootstock seedlings in the 1^{st} date (February) had leaves contained higher phosphorus level than those grafted in November. Such trend was true during both seasons of study, however, the differences between the two grafting dates (February or November) were significant in the second season (2009) only.

II.3- Leaf potassium content:

Referring the leaf potassium of Kalamata olive Cv. grafted on Shemlali olive rootstock seedlings in response grafting dates, it is quite evident from **Table (14)** that the same trend previously detected with phosphorus content was also observed with potassium. Hence, Kalamata olive Cv. grafted in the first grafting date (February)had richer leaves in their K content than those grafted in November. However, was significant during second 2009 season only. Meanwhile, in 2008 season, the response was completely absent from the statistical standpoint.

II.4- Leaf calcium content:

With respect to the influence of the different grafting dates on leaf calcium content of Kalamata olive Cv. **Table (14)** displays clearly that, leaf calcium content was relatively higher in Kalamata olive Cv. grafted on Shemlali olive rootstocks in the 1st grafting date (February). However, difference due to grafting dates was so few and did not reach level of significance during both seasons of study.

II.5- Leaf magnesium content:

Regarding the effect of the different grafting dates (February or November) on leaf magnesium content, data in **Table (14)** displayed obviously that the response typically followed the same trend previously detected with the leaf calcium content. Since, effectiveness in leaf magnesium content due to grafting date was not so pronounced to be concerned. Hence, differences were insignificant between the two investigated grafting dates during both 2008 and 2009 seasons of study.

II.6- Leaf iron content:

With respect to the influence of the grafting dates (either on (February or November) on leaf iron content of Kalamata olive Cv. grafted on Shemlali olive rootstocks, data tabulated in **Table (15)** revealed obviously that, leaf iron content didn't follow firm trend. Herein, two conflicted trends were noticed during both seasons, where leaf Fe content of Kalamata olive transplants in February was relatively richer than in 1st season, while the reverse was true in 2nd season whereas those of grafted plants in November were.

Table (14): Leaf macro elements (N, P, K, Ca and Mg) of Kalamata olive cultivar as affected by the different grafting dates during both 2008 and 2009 seasons.

Characters / Dates	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Calcium (%)	Magnesium (%)
The first season (2008)					
February	1.307A	0.200A	0.807A	1.577A	0.090A
November	1.283A	0.180A	0.787A	1.257A	0.077A
The second season (2009)					
February	1.477A	0.303A	1.193A	1.370A	0.086A
November	1.567A	0.207B	0.773B	1.290A	0.089A

Means followed by the same letter/s within each column are not significantly different from each other at 0.05 level.

Table (15): Leaf micro nutrients (Zn, Fe and Mn) of Kalamata olive cultivar as affected by grafting dates during both 2008 and 2009 seasons.

Characters / Dates	Iron (ppm)	Zink (ppm)	Manganese (ppm)
The first season (2008)			
February	150.5A	20.19A	36.84A
November	145.1B	17.14B	32.41B
The second season (2009)			
February	151.0B	25.77A	39.73A
November	161.8A	20.20B	36.81B

Means followed by the same letter/s within each column are not significantly different from each other at 0.05 level.

IV.II.7- Leaf zinc content:

Concerning the leaf zinc content of Kalamata olive Cv. grafted on Shemlali olive rootstocks in response to grafting dates (February & November), it is obvious from results of **Table (15)** that, the highest value of leaf zinc content was significantly in concomitant to Kalamata olive Cv. grafted on Shemlali olive rootstock in February, while the opposite was true with those grafted in November. Such trend was detected during both 2008 and 2009 seasons.

II.8- Leaf manganese content:

As for the leaf manganese content of Kalamata olive Cv. grafted on Shemlali olive rootstocks in response to the effect of two investigated grafting dates (February & November), it could be noticed clearly from data represented in the **Table (15)** that leaf manganese content responded significantly. Herein, Kalamata olive Cv. grafted in the 1st grafting date (February) had leaves contained significantly higher than those of grafted plants in the second grafting date (November).

IV.III - Photosynthetic pigments (foliar pigments).

IV.III.1- Chlorophyll (A and B).

Leaf chlorophyll (A and B), total chlorophyll (A + B) and carotenoids contents of Kalamata olive Cv. grafted on Shemlali olive rootstock seedlings in response to grafting dates (February & November) were investigated. Data obtained during both 2008 and 2009 experimental seasons are represented in **Table (16)**.

As for the effect of the grafting dates on leaf chlorophyll A content of Kalamata olive Cv. grafted on Shemlali olive rootstock, data obtained revealed clearly that, leaves of Kalamata olive Cv. grafted in the first grafting date (February) had higher levels of chlorophyll A content as compared to the analogous one which grafted in the second grafting date (November). However, differences were significant during two seasons of study.

With regard to the effect of the grafting date (either February or November) on leaf chlorophyll B content of Kalamata olive Cv. grafted on Shemlali olive rootstock, obtained data in the same Table displayed obviously, that leaves of Kalamata olive Cv. grafted in the 1^{st} grafting date i.e., (February) was significantly higher that those leaves of Kalamata olive Cv. grafted in the 2^{nd} grafting date (November). Such trend was detected during both 2008 and 2009 experimental seasons.

Referring the response of total chlorophyll (A + B) content of Kalamata olive Cv. grafted on Shemlali olive rootstocks to the different grafting dates under study, data obtained during both 2008 and 2009 seasons as shown from **Table (16)** pointed out clearly that, the total chlorophyll (A + B) content of leaves followed typically the same trends previously discussed with both chlorophyll A and chlorophyll B contents. Such trend was true during both the first and second seasons of study.

IV.III.2- Carotenoids:

Referring the leaf carotenoids content of Kalamata olive Cv. grafted on Shemlali olive rootstock in response to the investigated grafting dates i.e., (February & November), it is quite evident from as shown **Table (16)** that a firm trend was obviously detected. Since, the richest leaves in their carotenoids

Table (16): Leaf photosynthtic pigments (chlorophyll A, B and carotenoids) content of Kalamata olive cultivar as affected by grafting dates during both 2008 and 2009 seasons.

Characters / Dates	Chlorophyll (a)	Chlorophyll (b)	Total chlorophyll	Carotenoids
The first season (2008)				
February	7.33A	7.16A	14.50A	5.41A
November	5.42B	6.34B	11.76B	4.37B
The second season (2009)				
February	6.42A	6.38A	12.80A	5.95A
November	4.37B	5.22B	9.59B	4.44B

Means followed by the same letter/s within each column are not significantly different from each other at 0.05 level.

content of Kalamata olive Cv. was significantly exhibited by those grafted in the first grafting date (February). Meanwhile, the opposite was true with those grafted in the second grafting date (November) which induced statistically the lowest value and the poorest leaves in their caroteniods content. Moreover, it could be noticed that, differences were significant as each grafting dates were compared both other. Such trend was true during both 2008 and 2009 experimental seasons.

IV.IV- Some chemical constituents:

Total carbohydrates, total starch, total indoles and total phenols were the investigated four chemical properties of Kalamata olive Cv. grafted on Shemlali olive rootstock regarding their response to grafting dates under study i.e., (February & November).

IV.IV.1- Total carbohydrates:

Referring the effect of different grafting dates under study (February & November) on the total carbohydrates of Kalamata olive Cv. grafted on Shemlali olive rootstocks, **Table (17)** shows the pronounced relationship. Herein, the total carbohydrate of Kalamata olive Cv. grafted in the first grafting date (February) induced stem had the highest total carbohydrate, while those grafted in the second grafting date (November) in this concern. Moreover, differences in total carbohydrates due to grafting dates were significant as they compared each other during both seasons of study.

IV.IV.2- Total starch:

With respect to the effect of various grafting dates under study i.e., (February & November) on the total starch of Kalamata olive Cv. grafted on Shemlali olive rootstocks, data obtained as shown from **Table (16)** displayed obviously that the response typically followed the same trend previously detected with the total carbohydrates. Since the greatest value of total starch was always in concomitant to the Kalamata olive Cv. grafted in the first grafting date (14.55 & 16.97). Meanwhile, the reverse was true with those grafted in November during both seasons of study. Moreover, the differences between the two investigated grafting dates (February & November) were significant as they compared each other.

IV.IV.3- Total indoles:

Data obtained during both 2008 and 2009 seasons of as shown from **Table (17)** declared that total indoles of Kalamata olive Cv. grafted on Shemlali olive rootstock responded significantly to the different investigated grafting dates under study. As the first grafting date (February) exhibited statistically the highest values of total indoles (13.26 and 12.64), however, those in the second date (November) showed statistically the least values of total indoles i.e., (9.32 and 10.67) during both seasons. In addition to that, the variations between the two grafting dates were significant as they compared each other. Such trend was true during both 2008 and 2009 experimental seasons.

IV.IV.4- Total phenols:

Considering the effect of two investigated grafting dates on total phenols of Kalamata olive Cv. grafted on Shemlali olive rootstock, **Table (17)** shows obviously that, the Kalamata olive Cv. grafted in the second grafting date i.e., (November) contained the highest values of total phenols, while the least total phenols content was in closed relationship to those grafted in the first grafting date (February). Moreover, the differences

Table (17): Total carbohydrates, starch, total indoles and phenols of Kalamata olive cultivar as affected by grafting dates during both 2008 and 2009 seasons.

Characters / Dates	Total carobhydrate	Starch	Tota indoles	Total phenols
The first season (2008)				
February	24.18A	14.55A	13.26A	120.6B
November	20.28B	11.05B	9.32B	187.2A
The second season (2009)				
February	22.84A	16.97A	12.64A	139.3B
November	19.93B	12.53B	10.67B	194.8A

Means followed by the same letter/s within each column are not significantly different from each other at 0.05 level.

were significant as two grafting dates (February and November) compared each other regarding their effect on the total phenols content during both 2008 and 2009 seasons of study.

These results are in general agreement with those mentioned by **Aldarwish (2002).**

IV.V- Anatomical study of olive.

As for grafting Kalmata olive scion on Chemlali olive rootstock, data in **Table (18)** and **Fig. (4)** revealed that, diameter of whole section, rootstock thickness, scion thickness, cortex thickness in rootstock, scion cortex thickness, cambium thickness in rootstock and xylem tissue thickness in rootstock were increased with increase the transplant age. On the contrary, vacuoles and necrotic tissues decreased with increase the transplant age.

These results are in line with those obtained by **Hartmann and Kester (1978) and Shklarman *et al.*, (1994)** who declared that compatible and incompatible combinations of citrus species cannot affect satisfactory union which takes place after a year and it can be detected at an early stage. Moreover, **Fortanzza and Rugini (1983)** stated that, under compatible conditions the success of graft depends, from histological point of view, on vascular differentiation at the bud union zone. **Bakry *et al.*, (2006)** reported that, microscopic examination of union zone between Sour orange interstock and Volkamer lemon rootstock showed also wider parenchymatous vacuoles and necrotic tissues, besides narrower area of different union zone tissues, particularly secondary cortex were presented which gave a logic explanation for the depressive influence of Sour orange interstock on most growth parameters. However, the union process took place successfully.

Table (18): Some anatomical measurements of cross section in union zone for Klmata olive scion on Chemlali olive rootstock in February 2009.

Transplant age / Measurements (microns)	1 month	2 months	4 months	6 months
Diameter of whole section	7140.60	7390.80	8208.00	9117.00
Rootstock thickness	3760.20	3881.70	3834.00	4082.40
Scion thickness	3258.90	3630.60	4374.00	5034.60
Cortex thickness in rootstock	102.60	160.20	167.20	181.80
Scion cortex thickness	61.56	92.34	123.12	164.16
Cambium thickness in rootstock	36.90	53.10	59.40	99.00
Xylem tissue thickness in rootstock	814.50	936.00	1078.20	1348.20
Secondary cortex thickness	112.70	165.60	169.40	266.40
Union zone thickness	59.40	144.00	193.50	202.50
No. of vacuoles	1	1	-	-
Vacuoles thickness	126.90	56.25	-	-
Thickness of necrotic layer	113.40	68.40	-	-

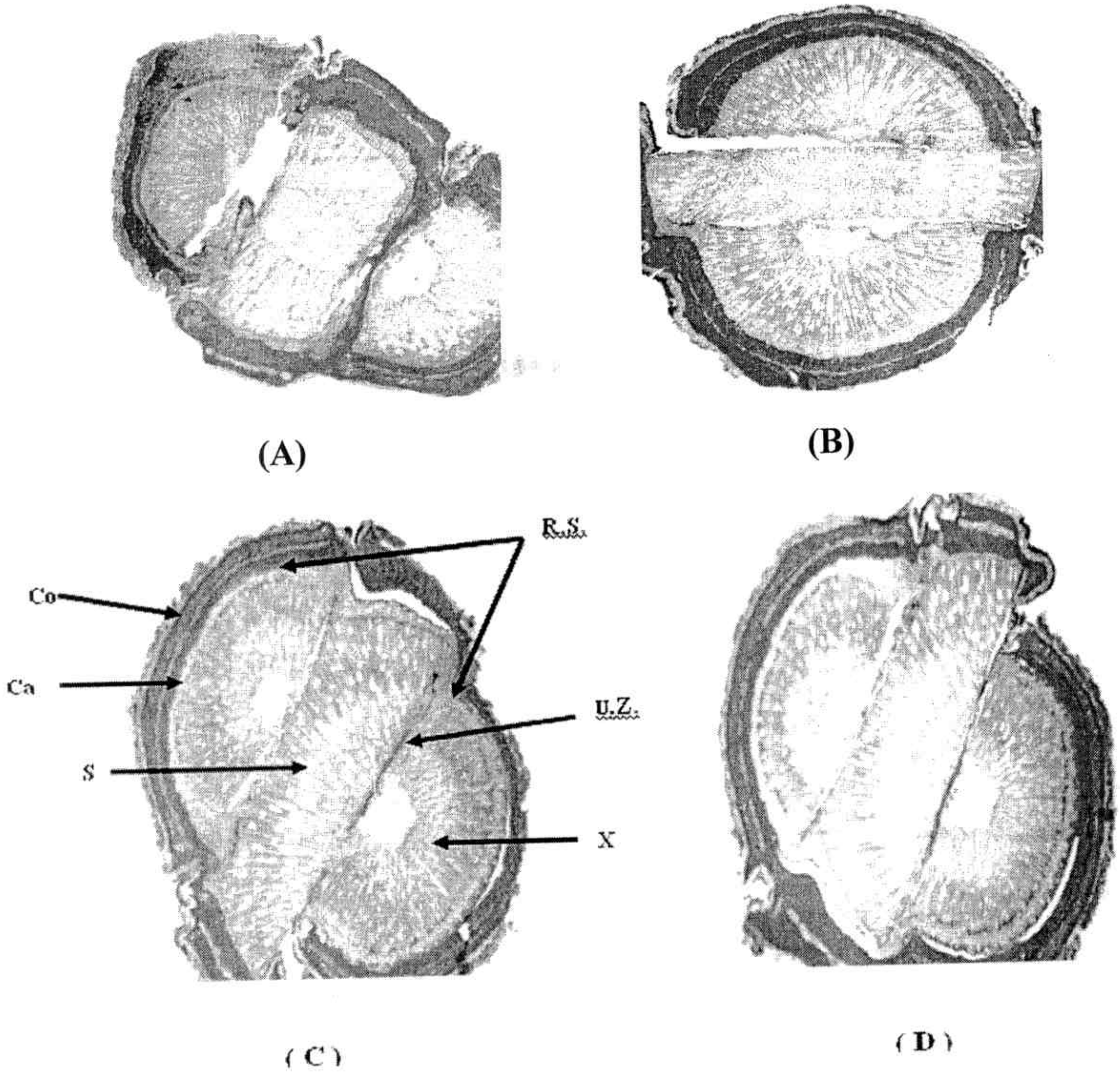


Fig. (4): Cross section in union zone for Kalamata olive scion on shemlali olive rootstock (X= 50).

A- at 1 month age. B- at 2 month age.

C- at 4 month age. **D-** at 6 month age.

S = Scion, R.S. = Rootstock, Co = Cortex, Ca= Cambium X. = Xylem, U.Z. = Union zone, V. = vacuoles, N. = Necrotic layer.